SUBSECTION 8.16

Paleontological Resources

8.16 Paleontological Resources

8.16.1 Introduction

Paleontological resources (fossils) are the remains or traces of prehistoric animals and plants. Fossils are important scientific and educational resources because of their use in (1) documenting the presence and evolutionary history of particular groups of now extinct organisms, (2) reconstructing the environments in which these organisms lived, (3) and in determining the relative ages of the strata in which they occur. Fossils are also important in determining the geologic events that resulted in the deposition of the sediments that entombed them and their subsequent deformation.

This section of the AFC summarizes the potential environmental impacts on paleontological resources that may result from construction of CVEC. Section 8.16.2 lists the federal and state LORS and the professional standards that protect paleontological resources. Section 8.16.3 describes the existing environment that could be affected by the CVEC project. Section 8.16.4 describes the potential impacts on paleontological resources resulting from construction and operation of the proposed project. The cumulative impacts to paleontological resources are discussed in Section 8.16.5. Proposed mitigation measures to reduce potential adverse impacts to paleontological resources are discussed in Section 8.16.6. The involved agencies and agency contacts are provided in Section 8.16.7. Section 8.16.8 discusses the status of permits required and permit schedule. Finally, Section 8.16.9 lists the references used in preparing this document.

This paleontological resources inventory and impact assessment was prepared by Dr. Lanny H. Fisk, PhD, RG, a California registered geologist, senior paleontologist, and a principal of PaleoResource Consultants (PRC). It meets all requirements of the CEC (CEC, 2000) and the standard measures for mitigating adverse construction-related environmental impacts on significant paleontological resources established by the Society of Vertebrate Paleontology (SVP, 1991, 1995, 1996).

8.16.2 Laws, Ordinances, Regulations, and Standards

Paleontological resources are classified as non-renewable scientific resources and are protected by several federal and state statutes (California Office of Historic Preservation, 1983; Marshall, 1976; Fisk and Spencer, 1994), most notably by the 1906 Federal Antiquities Act and other subsequent federal legislation and policies and by the State of California's environmental regulations (CEQA, Section 15064.5). Professional standards for assessment and mitigation of adverse impacts on paleontological resources have been established by the SVP (1991, 1995, 1996). Design, construction, and operation of the proposed project, including ancillary facilities, will be conducted in accordance with LORS applicable to paleontological resources. Federal and state LORS applicable to paleontological resources are summarized in Table 8.16-1 and discussed briefly below, together with SVP professional standards.

8.16.2.1 Federal LORS

Federal protection for significant paleontological resources would apply to the project if any construction or other related project impacts occurred on federally owned or managed lands. Federal legislative protection for paleontological resources stems from the Antiquities Act of 1906 (PL 59-209; 16 United States Code [USC] 431 et seq.; 34 Stat. 225), which calls for protection of historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest on federal land.

TABLE 8.16-1
LORS Applicable to Paleontological Resources

Project LORS	Purpose	Applicability (AFC Section Explaining Conformance)
Antiquities Act of 1906	Protects paleontological resources on federal lands	Section 8.16.6
CEQA	Fossil remains may be encountered by earth-moving	Section 8.16.6
Public Resources Code Sections 5097.5/5097.9	Would apply only if some project land were acquired by the State of California	Not applicable (Section 8.16.6)

8.16.2.2 State LORS

The CEC environmental review process under the Warren-Alquist Act is considered functionally equivalent to that of the California Environmental Quality Act (CEQA; Public Resources Code Sections 15000 et seq.) with respect to paleontological resources. Guidelines for the Implementation of CEQA, as amended March 29, 1999 (Title 14, Chapter 3, California Code of Regulations: 15000 et seq.) define procedures, types of activities, persons, and public agencies required to comply with CEQA, and include as one of the questions to be answered in the Environmental Checklist (Section 15023, Appendix G, Section XIV, Part a) the following: “Will the proposed project disturb paleontological resources?”

Other state requirements for paleontological resources management are in Public Resources Code Chapter 1.7, Section 5097.5, Archaeological, Paleontological, and Historical Sites. This statute specifies that state agencies may undertake surveys, excavations, or other operations as necessary on state lands to preserve or record paleontological resources and defines any unauthorized disturbance or removal of a fossil site or remains on public land as a misdemeanor. It would apply to the CVEC project if the state or a state agency were to obtain ownership of project lands during the term of the project license or if construction of the project linear features (natural gas pipeline and/or water pipeline) were built on county- or state-owned lands, such as on highway right-of-ways.

8.16.2.3 Local LORS

Neither Fresno County or the City of San Joaquin has mitigation requirements that specifically address potential adverse impacts to paleontological resources.

8.16.2.4 Professional Standards

The SVP, a national scientific organization of professional vertebrate paleontologists, has established standard guidelines (SVP, 1991, 1995, 1996) that outline acceptable professional practices in the conduct of paleontological resource assessments and surveys, monitoring and mitigation, data and fossil recovery, sampling procedures, and specimen preparation, identification, analysis, and curation. Most practicing professional paleontologists in the nation adhere closely to the SVP’s assessment, mitigation, and monitoring requirements as specifically spelled out in its standard guidelines. Most California state regulatory agencies accept the SVP standard guidelines as a measure of professional practice.

8.16.3 Affected Environment

8.16.3.1 Geographic Location

The site proposed for construction of the CVEC is at a rural location approximately 0.5 mile south of the City of San Joaquin in central Fresno County, California. The approximate location of the proposed CVEC power plant is latitude 36°35'50"N, longitude 120°1'20"W, in the SE quarter of the NW quarter of Section 25, T. 15 N., R. 16 E. in the U.S. Geological Survey (USGS) San Joaquin 7.5-minute (1:24,000 scale) Quadrangle. The site is located on the basin plain of the San Joaquin Valley, very near the geographic center of the State of California. The San Joaquin Valley comprises roughly the southern two thirds of the major north-northwest oriented synclinorium called either the Valle Grande (Clark, 1929), Great Valley (Fenneman, 1931; Hackel, 1966), Great Interior Valley (Harradine, 1950), Central Valley (Jahns, 1954), Great Central Valley (Piper et al., 1939; Davis et al., 1957), or California Trough (Piper et al., 1939). The Central Valley Physiographic Province is located between the Sierra Nevada Physiographic Province on the east and the Coast Ranges Physiographic Province on the west. The general project area is bounded on the west by the nearly flat basin floodplain of the Fresno Slough, a diversion of the Kings River. Beyond the Fresno Slough further to the west is a gently inclined alluvial fan, the Cantua Fan (Jennings and Strand, 1958) or Cantua Creek Fan (Bull, 1964), which lies at the base of low-lying foothills of the Coast Range. To the east of the proposed CVEC power plant site is an even more gently inclined alluvial fan built up by both the Kings River and Upper San Joaquin River and adjacent smaller streams, all of which head in the Sierra Nevada. The area in the immediate vicinity of the proposed plant site is irrigated farmland with the primary crop being cotton. To the east and west of the basin floodplain drier soils are increasingly being planted to grape vineyards.

8.16.3.2 Regional Geologic Setting

The general geology of the San Joaquin Valley has been described in some detail by Hoots et al. (1954), Davis et al. (1957, 1959), Hoffman (1964), Croft and Wahrhaftig (1965), Hackel (1966), Marchand (1977), and Lettis (1982), among others. The information in these and other published reports form the basis of the following discussion. Individual publications are incorporated into this report and referenced where appropriate. For obtaining the older geological literature, the exhaustive compilation entitled "*Geological Literature on the San Joaquin Valley of California*" by Maher et al. (1973) was particularly helpful.

The geology in the vicinity of the proposed site of the Central Valley Energy Center has been mapped or described by numerous workers, including Anderson (1911), Anderson and Pack (1915), Mendenhall et al. (1916), Jennings and Strand (1958), Bull (1964), Davis et al. (1957, 1959), Miller (1971), Croft (1972), and Chin et al. (1993). Surficial geologic mapping of the project site and vicinity has been provided at a scale of 1:750,000 by Jennings (1977); at a scale of 1:500,000 by Jenkins (1938); at a scale of 1:250,000 by Jennings and Strand (1958) and Chin et al. (1993); at a scale of 1:125,000 by Anderson and Pack (1915); and at a scale of 1:62,500 by Dibblee (1971). No 1:24,000-scale geologic maps are currently available for this area. The site-specific geology of the CVEC site is discussed in Section 8.16.3.5. The aspects of geology pertinent to this report are the types, distribution, and age of sediments immediately underlying the project area and their probability of producing fossils during project construction.

The San Joaquin Valley is a great structural depression between the westerly tilted Sierra Nevada block on the east and the complexly folded and faulted Coast Ranges on the west. The Valley is filled with thick Mesozoic and Tertiary marine sediments covered by a relatively thin veneer of Quaternary alluvial sediments (Bailey, 1966).

The west margin of the Central Valley is a discontinuous series of individual and coalescing alluvial fans, with their apices located where streams drain the eastern foothills of the Coast Range. These low relief alluvial fans form a nearly continuous belt between the dissected uplands of the Coast Range and the nearly flat basin plain of the San Joaquin Valley. They are composed of undeformed to slightly deformed alluvial deposits laid down primarily during Plio-Pleistocene time. Each alluvial fan consists of a mass of coarse to fine rock debris that splays outward from the mouth of its primary stream channel onto the valley floor as a fan-like deposit of well-sorted sand and gravel encased in a matrix of finer sediments, chiefly poorly sorted fine sand and silt deposited away from the stream channels on the alluvial plain. Our current interpretations and understanding of the alluvial deposits of major rivers flowing into the Central Valley lies in Arkley's (1962, 1964) studies of the Merced, Tuolumne, and Stanislaus River fans, Bull's (1964) study of alluvial fans along the western margin of the Central Valley, Janda's (1966; Janda and Croft, 1965) study of alluvium of the upper San Joaquin River, Shlemon's (1967) study of the American River fan, Atwater's (1980) study of the Mokelumne River fan, and Lettis' (1982) study of alluvial fans along the west central margin of the San Joaquin Valley.

The alluvial deposits accumulated on alluvial fans along the western margin of the Central Valley consist of coarse- to fine-grained sediment eroded from Tertiary and older volcanic, plutonic, and metamorphic rocks in the mountains to the west (Bull, 1964; Lettis, 1982). The alluvial fan deposits grade east- or slightly northeast-ward through gradually decreasing grain sizes from coarse pebble to cobble gravel at the Coast Range foothills to clay-rich silt on the San Joaquin Valley basin plain. The gravel, sand, silt, and clay that compose these alluvial fans have in the past produced abundant fossils, primarily large land mammals such as mammoths, mastodons, camels, bison, and horses. These paleontological resources are discussed below.

8.16.3.3 Resource Inventory Methods

To develop a baseline paleontological resource inventory of the CVEC site and surrounding area and to assess the potential paleontological productivity of each stratigraphic unit present, the published as well as available unpublished geological and paleontological literature was reviewed; and stratigraphic and paleontologic inventories were compiled, synthesized, and evaluated (see below). These methods are consistent with CEC (2000) and SVP (1995) guidelines for assessing the importance of paleontological resources in areas of potential environmental effect. No subsurface exploration was conducted for this assessment. Stratigraphy was observed in numerous road cuts, walls of irrigation ditches and ponds, and natural stream banks during site surveys on 20 and 23 June and 15 and 16 July 2001.

Geologic maps and reports covering the bedrock and surficial geology of the project site and vicinity were reviewed to determine the exposed and subsurface rock units, to assess the potential paleontological productivity of each rock unit, and to delineate their respective areal distribution in the project area. In addition, available soil surveys and aerial photographs of the area were examined to aid in determining the areal distribution of distinctive sediment and soil types.

The number and locations of previously recorded fossil sites from rock units exposed in and near the project site and the types of fossil remains each rock unit has produced were evaluated based on published and unpublished geological and paleontological literature (including previous environmental impact assessment documents and paleontological resource impact mitigation program final reports). The literature review was supplemented by an archival search conducted at the University of California Museum of Paleontology (UCMP) in Berkeley, California, for additional information regarding the occurrence of fossil sites and remains in and near the project site.

Field surveys, which included a visual inspection of exposures of potentially fossiliferous strata in the project area, were conducted to document the presence of sediments suitable for containing fossil remains and the presence of any previously unrecorded fossil sites. The field surveys for this assessment were conducted on 20 and 23 June and 15 and 16 July 2001 by Dr. Lanny H. Fisk, PhD, RG, senior paleontologist with PRC.

8.16.3.4 Paleontological Resource Assessment Criteria

The SVP (1995), in common with other environmental disciplines such as archeology and biology (specifically in regard to listed species), considers any fossil specimen significant, unless demonstrated otherwise, and, therefore, protected by environmental statutes. This position is held because vertebrate fossils are uncommon and only rarely will a fossil locality yield a statistically significant number of specimens representing the same species. In fact, vertebrate fossils are so uncommon that, in most cases, each fossil specimen found will provide additional important information about the characteristics or distribution of the species it represents.

A stratigraphic unit (such as a formation, member, or bed) known to contain significant fossils is considered to be "sensitive" to adverse impacts if there is a high probability that earth-moving or ground-disturbing activities in that rock unit will either disturb or destroy fossil remains. This definition of sensitivity differs fundamentally from that for archeological resources:

> *"It is very important to make the distinction between archaeologic resource sites and paleontologic resource sites when defining sensitivity. Archaeologic site boundaries define the limit of the extent of the resource. Paleontologic sites, however, serve as indicators that the sedimentary unit or formation in which they are found is fossiliferous. The boundaries of an entire fossiliferous formation, therefore, define the limits of paleontologic sensitivity in a given region." (SVP, 1991).*

This distinction between archeological and paleontological sites is important. Most archeological sites have a surface expression that allow for their geographic location. Fossils, on the other hand, are an integral component of the rock unit below the ground surface, and, therefore, are not observable unless exposed by erosion or human activity. Thus, a paleontologist cannot know either the quality or quantity of fossils present before the rock unit is exposed as a result of natural erosion processes or earth-moving activities. The paleontologist can only make conclusions on sensitivity to impact based upon what fossils have been found in the rock unit in the past, along with a judgment on whether or not the depositional environment of the sediments that compose the rock unit was likely to result in the burial and preservation of fossils.

Fossils are seldom uniformly distributed within a rock unit. Most of a rock unit may lack fossils, but at other locations within the same rock unit concentrations of fossils may exist. Even within a fossiliferous portion of the rock unit, fossils may occur in local concentrations. For example, Shipman (1977, 1981) excavated a fossiliferous site using a three dimensional grid and removed blocks of matrix of a consistent size. The site chosen was known prior to excavation to be richly fossiliferous, yet only 17 percent of the blocks actually contained fossils. These studies demonstrate the physical basis for the difficulty in predicting the location and quantity of fossils in advance of project-related ground disturbance.

Since it is unfortunately not possible to determine where fossils are located without actually disturbing a rock unit, monitoring of excavation by an experienced paleontologist during construction increases the probability that fossils will be discovered and preserved. Preconstruction mitigation measures such as surface prospecting and collecting will not prevent adverse impacts on fossils because many sites will be unknown in advance due to an absence of fossils at the surface.

The non-uniform distribution of fossils within a rock unit is essentially universal and many paleontological resource assessment and mitigation reports conducted in support of environmental impact documents and mitigation plan summary reports document similar findings (see for instance

Lander, 1989, 1993; Reynolds, 1987, 1990; Spencer, 1990; Fisk et al., 1994; and references cited therein). In fact, most fossil sites recorded in reports of impact mitigation (where construction monitoring has been implemented) had no previous surface expression. Because the presence or location of fossils within a rock unit cannot be known without exposure resulting from erosion or excavation, under SVP (1991, 1995) standard guidelines, an entire rock unit is assigned the same level of sensitivity based on recorded fossil occurrences.

Using SVP (1995) criteria, the paleontological importance or sensitivity (high, low, or undetermined) of each rock unit exposed in a project site or surrounding area is the measure most amenable to assessing the significance of paleontological resources because the areal distribution of each rock unit can be delineated on a topographic or geologic map. The paleontological importance of a stratigraphic unit reflects: (1) its potential paleontological productivity (and thus sensitivity), and (2) the scientific significance of the fossils it has produced. This method of paleontological resources assessment is the most appropriate because discrete levels of paleontological importance can be delineated on a topographic or geologic map.

The potential paleontological productivity of a stratigraphic unit exposed in a project area is based on the abundance/densities of fossil specimens and/or previously recorded fossil sites in exposures of the unit in and near a project site. The underlying assumption of this assessment method is that exposures of a stratigraphic unit in a project site are most likely to yield fossil remains both in quantity and density similar to those previously recorded from that stratigraphic unit in and near the project site.

An individual fossil specimen is considered scientifically important if it is:

- Identifiable,
- Complete,
- Well preserved,
- Age diagnostic,
- Useful in paleoenvironmental reconstruction,
- A type or topotypic specimen,
- A member of a rare species,
- A species that is part of a diverse assemblage, and/or
- A skeletal element different from, or a specimen more complete than, those now available for that species.

Identifiable land mammal fossils are considered scientifically important because of their potential use in providing accurate age determinations and paleoenvironmental reconstructions for the sediments in which they occur. Moreover, vertebrate remains are comparatively rare in the fossil record. Although fossil plants are usually considered of lesser importance because they are less helpful in age determination, they are actually more sensitive indicators of their environment (Miller, 1971) and, thus, as sedentary organisms, more valuable than mobile animals for paleoenvironmental reconstructions. For marine sediments, invertebrate and marine algal fossils, including microfossils, are scientifically important for the same reasons that land mammal and/or land plant fossils are valuable in terrestrial deposits. The value or importance of different fossil groups varies depending on the age and depositional environment of the stratigraphic unit that contains the fossils.

The following tasks were completed to establish the paleontological importance and sensitivity of each stratigraphic unit exposed in or near the project site:

- The potential paleontological productivity of each rock unit was assessed based on the density of fossil remains and/or previously recorded and newly documented fossil sites it contains in and/or near the project site.
- The scientific importance of fossil remains recorded from a stratigraphic unit exposed in the project site was assessed.
- The paleontological importance of a rock unit was assessed, based on its documented and/or potential fossil content in the area surrounding the project site.

8.16.3.4.1 Categories of Sensitivity

In its standard guidelines for assessment and mitigation of adverse impacts to paleontological resources, the SVP (1995) established three categories of sensitivity for paleontological resources: high, low, and undetermined.

High Sensitivity

Stratigraphic units in which fossils have been previously found have a high potential to produce additional fossils and are therefore considered to be highly sensitive. In areas of high sensitivity, full-time monitoring is recommended during any project-related ground disturbance.

Low Sensitivity

Stratigraphic units that are not sedimentary in origin or that have not been known to produce fossils in the past are considered to have low sensitivity. Monitoring is usually not recommended nor needed during project construction through a stratigraphic unit with low sensitivity.

Undetermined Sensitivity

Stratigraphic units that have not had any previous paleontological resource surveys or any fossil finds are considered to have undetermined sensitivity. After reconnaissance surveys, observation of artificial exposures (such as road cuts) and natural exposures (such as stream banks), and possible subsurface testing (such as augering or trenching), an experienced, professional paleontologist can often determine whether the stratigraphic unit should be categorized as having high or low sensitivity.

In keeping with the significance criteria of the SVP (1995), all vertebrate fossils are categorized as having significant scientific value and all stratigraphic units in which vertebrate fossils have previously been found have high sensitivity.

8.16.3.5 Resource Inventory Results

8.16.3.5.1 Stratigraphic Inventory

Regional geologic mapping of the proposed CVEC project site and vicinity has been provided by Jenkins (1938; 1:500,000 scale), Jennings and Strand (1958; 1:250,000 scale), and Chin et al. (1993, 1:250,000 scale). Larger scale mapping of the project site has been provided by Dibblee (1971; 1:62,500 scale). Unfortunately, in their geologic maps of the Late Cenozoic deposits of the project area, geologists have not always used formally named stratigraphic units, nor have they consistently used the same map units.

Jennings and Strand (1958, 1:250,000 scale) simply mapped the area in the vicinity of the proposed project as Early Holocene “basin deposits” and “fan deposits.” Chin et al. (1993, 1:250,000 scale) mapped nearly the entire Cantua Creek alluvial fan and basin floodplain as Holocene “younger alluvium.” To the east of the CVEC site, Chin et al. (1993) mapped the eastern rim of the basin floodplain as Pleistocene "older alluvium." Finally, in the most detailed geologic mapping of the area, Dibblee (1971, 1:62,500 scale) mapped the entire Cantua Creek Fan as Holocene alluvium.

In the project vicinity, an alluvial fan has been created by rock debris deposited by Cantua Creek, and adjacent smaller streams, all of which drain off the foothills of the Coast Range. Geological materials composing the Cantua Creek alluvial fan and adjacent basin floodplain have been subdivided into stratigraphic units and named differently by different geologists. Fortunately, the difficulty in assigning a name to a stratigraphic unit does not affect its potential for producing significant paleontological resources. It only makes it more difficult to compare descriptions of fossil sites, which typically use either formally named stratigraphic units (formations and members) or North American Land Mammal Ages (NALMA), such as Blancan, Irvingtonian, or Rancholabrean.

The task of subdividing alluvial fan deposits into formal stratigraphic units is complicated by that fact that alluvial sediments are often lithologically similar. Davis and Hall (1959) addressed this problem by stating:

> *"An important problem in attempting to differentiate geologic units in alluvial areas is that the sediments often are derived from a common source and are deposited in similar environments. All or nearly all of the alluvium of the east side of the San Joaquin Valley is derived from granitic and associated rocks of the Sierra Nevada which lie to the east. Thus, the formations offer no textural or lithologic bases for subdivision. Nevertheless, the use of the topographic expression of the units in conjunction with the development of their soils makes it possible to define formations."*

In a doctoral dissertation at the University of California at Berkeley, which was also published as an U.S. Geological Survey Open-File Report, Lettis (1982) described and mapped the Late Cenozoic stratigraphy of alluvial fans and floodplain along the western margin of the central San Joaquin Valley from just north of the Cantua Creek Fan. Lettis' informally named stratigraphic units are well defined, correlated with named stratigraphic units elsewhere, and appear to also be directly applicable to the sedimentary sequence exposed on the Cantua Creek Fan and floodplain. Lettis divided the sedimentary deposits into five stratigraphic units. In order of decreasing age, these are the Plio-Pleistocene Tulare Formation; Middle to Late Pleistocene "Los Banos alluvium", which he correlated with the Riverbank Formation of Marchand and Allwardt (1981); the Late Pleistocene to possibly Early Holocene "San Luis Ranch alluvium", which he correlated with the Modesto Formation of Marchand and Allwardt (1981); and the Holocene "Patterson alluvium" and "Dos Palos alluvium." Since correlations with formally named formations appear to be well founded, I prefer to use the formal formation names of Marchand and Allwardt (1985), rather than the informally named units of Lettis (1982). I will refer to Lettis' "Patterson alluvium" and "Dos Palos alluvium" simply as unnamed Holocene alluvium.

Using the criteria of Lettis (1982), sediments composing the Cantua Creek alluvial fan and adjacent floodplain can be divided into four stratigraphic units, from oldest to youngest: the Pliocene Tulare Formation, exposed only on the uppermost alluvial fan; Middle to Late Pleistocene Riverbank Formation, also exposed only on the upper alluvial fan; Late Pleistocene to possibly Early Holocene Modesto Formation; and a thin veneer of unnamed Holocene alluvium. The latter three stratigraphic units overlie each other with increasing thickness on the lower portion of the alluvial fan and in the floodplain of the Fresno Slough. Each of these stratigraphic units has yielded fossil remains at previously recorded localities within the Central Valley.

Tulare and Riverbank Formations

The Plio-Pleistocene-age Tulare Formation and Middle to Late Pleistocene Riverbank Formations include the oldest alluvium within the Cantua Creek alluvial fan, but are not easily distinguished either from each other or from younger alluvial deposits that overly these units. The principal differences between the younger and older alluvial sediments are stratigraphic position, degree of consolidation, topographic expression, attitude (tilted versus flat-lying), and fossil content. According to Savage (1951), sediments in the greater San Francisco Bay area containing Late Pleistocene and Holocene fossil faunas can often be distinguished from older Pleistocene and Pliocene sediments by their relatively flat-lying attitude, while, in contrast, the older sediments containing Pliocene (Blancan NALMA) and Early to Middle Pleistocene (Irvingtonian NALMA) fossil faunas are often slightly tilted. This criterion has also been helpful to others in distinguishing older alluvium from younger alluvium (see for instance, Taliaferro, 1951; Davis et al., 1957; Hall, 1958; Miller, 1971; and Helley et al., 1972). Since sediments referred to the Tulare and Riverbank Formations are exposed only on the uppermost alluvial fan and are overlain by an increasing thickness of younger deposits on the lower fan and floodplain, they are not likely to be affected by CVEC project construction and will not be discussed further in this report.

Modesto Formation

The primarily Late Pleistocene Modesto Formation was first named by Davis and Hall (1959), who designated a type section along the south bluff of the Tuolumne River at the south edge of the City of Modesto. The Modesto Formation is composed of interbedded, largely unconsolidated, and poorly sorted, yellowish brown sandstone and siltstone with lesser amounts of pebble to cobble conglomerate. Marchand and Allwardt (1981) gave the age of the Modesto Formation between about 12,000 and 42,400 years BP, Late Pleistocene.

The Quaternary alluvium of the Cantua Creek alluvial fan assigned to the Modesto Formation is lithologically indistinct from the underlying Riverbank and Tulare Formations, but can be distinguished from them by stratigraphic position, degree of cementation (and therefore topographic expression), amount of deformation, and age. The Tulare Formation is believed to be Pliocene to possibly Early Pleistocene in age, while the age of the Riverbank Formation is probably Middle to Late Pleistocene, and the Modesto Formation is Late Pleistocene to possibly Early Holocene in age. Strata comprising both the Tulare and Riverbank Formations have been deformed by tectonic activity related to uplift of the Coast Range and can often be recognized from the overlying Modesto Formation by their non-flat-lying attitude. Because of its greater cementation, the older stratigraphic units also often have a distinct topographic expression. As Plio-Pleistocene uplift of the Coast Range occurred, it left exposed alluvial sediments of the Tulare and Riverbank Formations. As streams cut through these older deposits, remnants were preserved as topographic highs with valleys filled with Modesto Formation and younger sediments.

Unnamed Holocene Alluvium

The unnamed Holocene alluvium forms a thin veneer of gravel, sand, silt, and clay overlying the Modesto Formation on the lower portion of the Cantua Creek Fan and the adjacent floodplain of the Fresno Slough. It varies from only a few inches in thickness on the alluvial fan to over four feet on the floodplain and from uncemented gravel and sand on the alluvial fan to primarily clayey silt on the floodplain. On the floodplain, sediments derived from the Coast Range and transported eastward over the Cantua Creek Fan are mixed or interfinger with sediments derived from the Sierra Nevada and transported westward over the alluvial fan of the Upper San Joaquin River and Kings River. The contact of the unnamed Holocene alluvium with the underlying Modesto Formation is usually a sharp erosional unconformity on the well-cemented, silty sand known locally as the “Fresno Hardpan” (Hewes, 1946).

8.16.3.5.2 Site Geology

The proposed CVEC power plant site is underlain by continental basin deposits of Holocene age referred here to as “unnamed Holocene alluvium.” From soil profile descriptions by Harradine (1950) and Huntington (1971) and from personal observations of naturally eroded stream banks and the walls of irrigation ditches and other excavations, these Holocene “basin deposits” are underlain at a depth of about 48 inches by cemented sandstones referable to the Late Pleistocene Modesto Formation. Sediments of the Modesto Formation have yielded fossilized remains of extinct species of continental vertebrates at numerous previously recorded localities in the Central Valley (Fisk, 2000), including localities only a few miles from the proposed CVEC site.

Soil survey maps by Harradine (1950) and Huntington (1971) of the project site and vicinity indicate significant changes in soil types corresponding to changes in the underlying geology. For instance, soils over the proposed power plant site and vicinity were mapped as “Merced clay” by both Harradine (1950) and Huntington (1971). Merced soils developed on mixed igneous and sedimentary alluvium that has been deposited in the lowest portions of the valley basin. These soils developed on floodplains primarily as overbank flood deposits and were derived chiefly from granitic rocks in the Sierra Nevada. According to Huntington (1971), the fine-grained alluvial sediments upon which Merced Series soils formed were “deposited by the Kings River by way of the Fresno Slough in flood stage.”

Harradine (1950) and Huntington (1971) described typical soil profiles in Merced clay soil as consisting of dark-gray to black, micaceous, noncalcareous clay averaging about 12 inches thick, overlying up to 50 inches of olive-gray or light brown, mottled, highly micaceous, calcareous fine sandy clay. The substrata beneath Merced Series soils consist of yellowish-brown to pale yellow, mottled, stratified, highly micaceous, calcareous sands and silts that are often cemented to a hardpan or duripan by calcium carbonate and silica. This cemented zone is a paleosol (fossil soil), locally known as the “Fresno Hardpan” (Hewes, 1946) and a distinctive feature of Fresno area soils.

The typical Merced clay soil profile described by Harradine (1950) and Huntington (1971) is well exposed in the walls of a pond found in the field behind the Desman warehouse located at 9165-B South Colusa Avenue in the SE quarter of the NW quarter of Section 25, only 0.5 mile west-north-west of the proposed CVEC power plant site (see Confidential Appendix 8.16A). The walls of this roughly 60-foot by 80-foot pond expose a stratigraphic sequence approximately 15 feet thick consisting of a dark-grayish brown clay loam, overlying a light brown to olive-gray stratified silty clay, which extends downward to approximately 4 feet. The substrata beneath approximately 4 feet consist of mottled tan to orange- or yellow-brown, stratified, highly micaeous, silty sands that in the upper part are cemented by calcium carbonate. This cemented zone is the “Fresno Hardpan” at the top of the Modesto Formation.

To both the east and west of the Fresno Slough basin floodplain, the soils here referred to the “unnamed Holocene alluvium” become both thinner and far more complex, in part due to the “Fresno Hardpan” of the uppermost Modesto Formation being much closer to the surface along the basin rim and also due to the presence of eroded anticlines to the east of the town of San Joaquin (Jennings, 1977; Chin et al., 1993). These anticlines are indicated by thin soils overlying the “Fresno Hardpan” and by the presence of small oil fields along their eroded axis. Soils on the eastern basin rim were formed in moderately coarse granitic alluvium on the lower, western edge of alluvial fans deposited by the San Joaquin and Kings Rivers. Surficial deposits in this vicinity were mapped as Pleistocene “older alluvium” by Chin et al. (1993) and are here interpreted to be Modesto Formation. The ROWs of both the natural-gas pipeline and the cooling-water supply line traverse shallow sediments referred to the unnamed Holocene alluvium near the proposed CVEC power plant site and older sediments of the Modesto Formation both east and west of the basin floodplain of the Fresno Slough.

8.16.3.5.3 Paleontological Resource Inventory

An inventory of the paleontologic resources of each rock unit likely to be encountered either at the proposed CVEC project site or along the natural-gas pipeline or cooling-water supply line ROWs is presented below and the paleontological importance of these resources is assessed. The literature review and UCMP archival search conducted for this inventory documented no previously recorded fossil sites within the very limited footprint of the actual project site. However, a number of fossil sites were documented as occurring in sediments of either the unnamed Holocene alluvium or the Modesto Formation in other exposures of these units. In addition, fossil remains were found at several previously unrecorded fossil sites during the field survey of the proposed project site and vicinity conducted for this assessment.

Numerous vertebrate fossil localities have been reported from sediments referable to the Modesto Formation in the general vicinity of the proposed CVEC power plant in the San Joaquin and Sacramento Valleys. Many of these sites are documented in surveys of Quaternary land mammal fossils made by Stirton (1939, 1951), Hay (1927), Savage (1951), Lundelius et al. (1983), and Jefferson (1991b), or in surveys of Quaternary birds, reptiles, and amphibians made by Miller and DeMay (1953) and Jefferson (1991a). Mammalian fossils have been the most helpful in determining the relative age of alluvial deposits (Louderback, 1951; Savage, 1951).

Fossil vertebrates of Rancholabrean land-mammal age and fossil wood have previously been reported from sediments of the Modesto Formation near its type area (Garber, 1989; Jefferson, 1991b; Marchand and Allwardt, 1981) and at numerous other scattered locations in the Central Valley (Richards and McCrossin, 1991; Fisk and Lander, 1999; Lander, 1999). Jefferson (1991a, 1991b) compiled a data base of California Pleistocene (primarily Rancholabrean NALMA) vertebrate fossils from published records, technical reports, unpublished manuscripts, information from colleagues, and inspection of museum paleontological collections at over 40 public and private institutions. He listed only four sites in Fresno County that yielded Rancholabrean vertebrate fossils, including two UCMP localities. One of these localities is from a packrat midden in the foothills of the Sierra Nevada and not applicable to this study. In addition, two localities (Laguna Seca Ranch [UCMP locality V-81121] and Riverdale locality [UCMP V-65100]) are presumably from the Riverbank Formation, the latter from 90 feet in a water well, and also not applicable. The other fourth Fresno County locality is from the Modesto Formation (and possibly immediately overlying unnamed Holocene alluvium) and, therefore, is important to the present study. This fossil locality, known as the Tranquillity Locality (UCMP V-4410), is located approximately 6.8 miles northwest of the proposed CVEC site in a similar geologic setting in the floodplain of the Fresno Slough.

The Tranquillity Locality was originally discovered during excavation for the James Bypass, a flood-control canal that parallels the Fresno Slough and is also located 2.5 miles northeast of the proposed CVEC power plant site. This site has been described by Hewes (1943, 1946) and Irwin (1975) and collections of fossils are now found both at University of California at Berkeley and at the University of Pennsylvania. The Tranquillity Locality has produced fossils of fish, turtles, snakes, birds, moles, gophers, mice, wood rats, voles, jack rabbits, coyote, red fox, grey fox, badger, horse, camel, pronghorn antelope, elk, deer, and bison. The age of this fauna is Rancholabrean (Late Pleistocene) based primarily on the presence of *Bison* and *Camelops*, along with many mammalian species that are inhabitants of the same area today. Some of these fossils were recovered about 30 to 35 inches below the general land surface in “a [calcareous] hardpan matrix” referred to as the “Fresno Hardpan” by Hewes (1946). These specimens are clearly referable to the uppermost Modest Formation and Late Pleistocene in age. Other specimens were free from the matrix and, although “strikingly mineralized” (Hewes, 1946), may have come from the overlying unnamed Holocene alluvium. In other words, the Tranquillity fossil fauna may contain a mixture of both Pleistocene and Holocene animals.

These fossil remains from the Modesto Formation (and possibly immediately overlying unnamed Holocene alluvium) are scientifically highly significant because the taxa they represent previously had been unreported or only very rarely reported from the fossil record of California. Moreover, continental vertebrate remains are comparatively rare in the fossil record. In addition, paleontological data derived from a study of the fossil remains, in conjunction with geologic (particularly geochronologic, sedimentologic, and paleomagnetic) evidence, have been significant in documenting the origin and age of the Modesto Formation and in reconstructing the Pleistocene geologic history of the San Joaquin Valley.

During a field survey of prospective fossiliferous sediments near the project site on 23 June 2001, Dr. Fisk found weathered bones of land mammals, land snails, silicified wood, burrow casts, and root casts in the calcium-carbonate cemented “Fresno Hardpan” and underlying iron-silica cemented hardpans of the Modesto Formation exposed along the naturally eroded stream banks of James Bypass at Manning Road. This locality is east-northeast of the proposed CVEC site (see Confidential Appendix 8.16A) and along the ROW of the proposed alignment for the CVEC cooling-water supply line. At several other locations along the ROW of the cooling-water supply line, the “Fresno Hardpan” is exposed at or very near the surface and contains abundant burrow and root casts (ichnofossils). During a later field survey on 16 July 2001, Dr. Fisk also found burrow and root casts in the “Fresno Hardpan” exposed in the walls of a large pond located in the SE quarter of the NW quarter of Section 25, west-north-west of the proposed CVEC power plant site (see Confidential Appendix 8.16A).

In summary, since sediments referable to the Modesto Formation have yielded scientifically significant fossils in the past, since several previously unrecorded fossil localities were found as close as one-half mile from the proposed project site, and since depositional conditions appear to be favorable for the preservation of fossils, it is likely that additional significant paleontological resources will be found in sediments of either or both the Modesto Formation and overlying unnamed Holocene alluvium. Although no fossils are known to directly underlie the proposed project site, the presence of fossil sites in the Modesto Formation within one-half mile of the proposed project site and along the ROW of the proposed alignment for the CVEC cooling-water supply line suggests that there is a high potential for additional fossil remains to be uncovered by excavations during CVEC project construction. Because the Modesto Formation and possibly the overlying unnamed Holocene alluvium have produced significant fossils in the past, under SVP (1995) criteria both these stratigraphic units are judged to have high sensitivity. Additional identifiable fossil remains recovered from either the Modesto Formation or unnamed Holocene alluvium during project construction would be scientifically important and significant.

Identifiable fossil remains recovered during project construction could represent new taxa or new fossil records for the area, for the State of California, or for the stratigraphic unit. They could also represent geographic or temporal range extensions. Moreover, discovered fossil remains could make it possible to more accurately determine the age, paleoclimate, and depositional environment of the sediments from which they are recovered and document which taxa are from the Pleistocene Modesto Formation and which are from the unnamed Holocene alluvium. Finally, fossil remains recovered during project construction could provide a more comprehensive documentation of the diversity of animal and plant life that once existed in Fresno County and could result in a more accurate reconstruction of the geologic history of the Central Valley.

8.16.4 Environmental Consequences

8.16.4.1 Significance Criteria

A paleontological resource can be significant if:

- It provides important information on the evolutionary trends among organisms, relating living organisms to extinct organisms.
- It provides important information regarding development of biological communities or interaction between botanical and zoological biota.

- It demonstrates unusual circumstances in biotic history.
- It is in short supply and in danger of being depleted or destroyed by the elements, vandalism, or commercial exploitation, and is not found in other geographic localities.

Under CEQA guidelines, (PRC 15064.5 (a)(2)), public agencies must treat all historical and cultural resources as significant unless the preponderance of evidence demonstrates that they are not historically or culturally significant. In keeping with significance criteria of the SVP (1995), all vertebrate fossils are categorized as having significant scientific value.

8.16.4.2 Potential Impacts to Paleontological Resources

Potential impacts on paleontological resources resulting from construction of the proposed project can be divided into construction-related impacts and operation-related impacts. Construction-related impacts to paleontological resources primarily involve terrain modification (excavations and drainage diversion measures). Paleontologic resources, including an undetermined number of fossil remains and unrecorded fossil sites; associated specimen data and corresponding geologic and geographic site data; and the fossil-bearing strata, could be adversely affected by (i. e., would be sensitive to) ground disturbance and earth moving associated with construction of the project. Direct impacts would result from vegetation clearing, grading of roads and the generating facility site, trenching for pipelines, augering for foundations for electrical towers or poles, and any other earth-moving activity that disturbs or buries previously undisturbed fossiliferous sediments, making those sediments and their paleontologic resources unavailable for future scientific investigation. The potential environmental effects from construction and operation of the project on paleontological resources are presented in the following subsections.

8.16.4.2.1 Potential Impacts from Project Construction

The proposed project site and linear facility ROWs are located on Pleistocene and Holocene-age alluvial deposits of the fossiliferous Riverbank and Modesto Formations. Excavations deeper than about 4 feet at the proposed power plant site, such as those for foundations for turbines, trenching for the natural gas pipeline, the cooling-water supply pipeline, and electrical transmission line, have the potential to result in significant adverse impacts to paleontological resources. However, the construction of supporting facilities, such as temporary construction offices, laydown area, and parking areas, do not have potential to cause adverse impacts on significant paleontological resources, as they will not involve ground disturbance beneath the Holocene-Pleistocene contact, which locally is coincident with the “Fresno Hardpan.” Trenching for the natural gas pipeline has the potential to disturb Pleistocene alluvial sediments of the Riverbank and Modesto Formations that contains vertebrate fossils elsewhere. Finally, trenching for the cooling-water supply line and borings for electrical transmission line poles or towers could disturb Pleistocene sediments of the Modesto Formation that contains vertebrate fossils elsewhere. Thus, project-related ground disturbance could have adverse impacts on significant paleontological resources.

8.16.4.2.2 Potential Impacts from Project Operation

No impacts on paleontological resources are expected to occur from the continuing operation of the project or any of its related facilities.

8.16.5 Cumulative Impacts

If the project were to encounter paleontological finds during construction, the potential cumulative effect would be low, as long as mitigative measures were implemented to recover the resources. The mitigative measures proposed in Section 8.16.6 would effectively recover the value to science of significant fossils recovered.

8.16.6 Mitigation Measures

This section describes proposed mitigation measures that will be implemented to reduce potential adverse impacts to significant paleontological resources resulting from project construction. Mitigation measures are necessary because of potential adverse impacts of project construction on significant paleontological resources within the Tulare and Modesto Formations. The proposed paleontological resource impact mitigation program would reduce, to an insignificant level, the direct, indirect, and cumulative adverse environmental impacts on paleontologic resources that could result from project construction. The mitigation measures proposed below for the project are consistent with CEC environmental guidelines (CEC, 2000) and with SVP standard guidelines for mitigating adverse construction-related impacts on paleontologic resources (SVP 1995, 1996).

Prior to construction, a qualified paleontologist will be retained to both design a monitoring and mitigation program and implement the program during project-related earth-moving activities at the generating facility site, for deep boring for electrical transmission towers, and for construction of the water and natural gas pipelines, and for all other project-related ground disturbance. The paleontological resource monitoring and mitigation program will include construction monitoring; emergency discovery procedures; sampling and data recovery, if needed; museum storage of any specimen and data recovered; preconstruction coordination; and reporting. Prior to the start of construction, the paleontologist will conduct a field survey of exposures of sensitive stratigraphic units within the construction site that will be disturbed. Earth-moving construction activities will be monitored where this activity will disturb previously undisturbed sediment. Monitoring will not be conducted in areas where the ground has been previously disturbed or in areas where exposed sediment will be buried, but not otherwise disturbed.

Prior to the start of construction, construction personnel involved with earth-moving activities will be informed on the importance of the fossil record, on laws and regulations protecting fossils, on the appearance of fossils and the types of fossils likely to be seen during project construction, and on proper notification procedures should fossils be discovered. This worker training will be prepared and presented by a qualified paleontologist.

Implementation of these mitigation measures will reduce the potentially significant adverse environmental impact of ground disturbance and earth-moving on paleontological resources of the proposed project site to an insignificant level by allowing for the recovery of fossil remains and associated specimen data and corresponding geologic and geographic site data that otherwise might be lost to earth-moving and to unauthorized fossil collecting.

With a well designed and implemented paleontological resource monitoring and mitigation plan, project construction could actually result in beneficial effects on paleontological resources through the recovery of fossil remains that would not have been exposed without project construction and, therefore, would not have been available for study. The recovery of fossil remains as part of project construction could help answer important questions regarding the geographic distribution, stratigraphic position, and age of fossiliferous sediments in the project area.

8.16.7 Involved Agencies and Agency Contacts

There are no state or local agencies having specific jurisdiction over paleontological resources.

8.16.8 Permits Required and Permit Schedule

No state or local agency requires a paleontological collecting permit to allow for the recovery of fossil remains discovered as a result of construction-related earth moving on state or private land in a project site.

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